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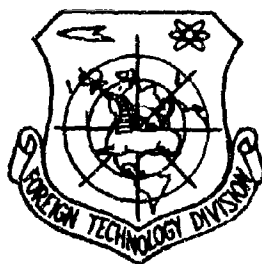
RETURN FROM SPACE TO EARTH

by

I. Lorincz

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ABSTRACT

The Soviet spacecraft reentry procedure as shown in Fig.-1 was developed in 1960 and no significant change has been made since. However, in the second and third generation of spaceships (Voskhod, Soyuz) the astronaut ejection seat has been omitted. To reduce the impact at landing, small retrorockets are used which complement the main parachute and reduce the velocity of fall from 10 m/sec to only a few cm/sec at the moment of contact.

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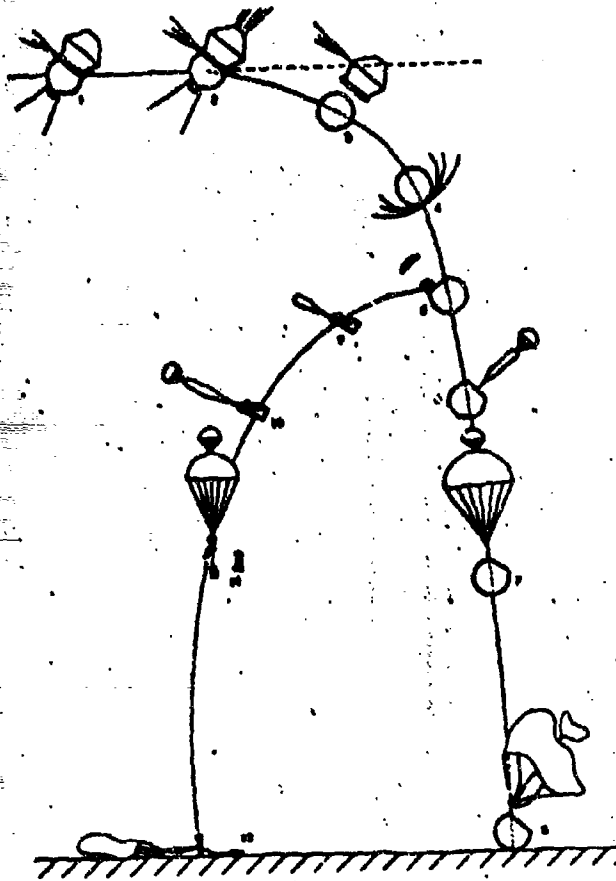


Fig. 1. Vostok spaceship reentry diagram

1 - Attitude control; 2 - retrorocket fires; 3-instrument section jettisons; 4 - further braking in space; 5 - astronaut ejects from capsule; 6 - drogue parachute of capsule opens; 7 - main parachute opens; 8 - landing at 10 m/sec; 9 - drogue parachute of seat opens; 10 - main parachute deploys; 11 - main parachute opens and astronaut separates from his seat carrying an instrument package; 12 - astronaut lands.

RETURN FROM SPACE TO EARTH

Istvan Lorincz

Thousands of people viewed the model of the Vostok spaceship, which carried Gagarin into space, while it was on display at the exhibit commemorating the "Fiftieth Anniversary of Soviet Science and Technology". Many of our readers called us up or wrote to our editors, inquiring about the reentry procedure used by the Vostok. One of our columnists, Istvan Lorincz, who is an expert in the field of rocket technology, will answer their questions in this article.

The development of a satellite reentry procedure was the vital problem which had to be solved before manned space flights could be attempted. Man could not be sent into space until a reliable method of bringing him back to Earth could be found. This was an extremely difficult task. The only economical reentry procedure is to allow the spacecraft to enter the denser layers of the atmosphere where the aerodynamic drag it would encounter, would cause the vehicle to decelerate. However, the kinetic energy of a high-velocity spacecraft is such that the heat generated by it is more than enough to melt it. For this reason, special attention must be paid to a means of dissipating this heat.

Experimental Spacecraft

In the Soviet Union, the spacecraft reentry procedure tested on the same type of satellite-spaceships as were later used in the first manned orbital flight.

On May 15, 1960, "Experimental Satellite-Spaceship I", weighing 4540 kilograms was launched. The craft, which was not recovered, was tracked for a week as it revolved in its orbit around the Earth. Then, the cabin was separated from the instrument section and upon reception of a ground command, the braking system went into action. However, due to faulty orientation, the ship changed its orbit instead of braking.

"Experimental Spaceship-Satellite II" was launched on August 19, 1960, into a 308/338 kilometer orbit. Within the cabin were two dogs and many other animals. It can, in fact, be described as a "space zoo". The day after its launching, the reentry procedure was tested and the retrorockets functioned with great precision. The complete space cabin was recovered. The return-to-earth operation was begun when it was 11,000 kilometers from the landing site. The thermal shield was effective in protecting the spacecraft against the tremendous heat. At an altitude of 7000 meters its speed was reduced to less than the speed of sound and in this way the critical phase of reentry was successfully completed. Next, the capsule containing the animals was separated and, with the aid of a parachute, it was brought to earth at a speed of 6 m/s. The capsule landed within 10 kilometers of the predetermined site. This was an extremely significant accomplishment. The Soviet scientists had succeeded in their first attempt to recover a spacecraft weighing more than two tons, as well as the capsule containing the animals who had orbited the Earth for twenty-four hours.

The passengers in the "Experimental Spaceship-Satellite III" were not blessed with the same good fortune. After spending one day revolving in its 187/265 kilometer orbit, the spacecraft entered the wrong reentry flight path and, after the braking system was set into motion, it burned up in the denser layers of the atmosphere. To date, this is the only failure related to reentry in the Soviet space program. It occurred during the critical phase of the return-to-earth operation, as the craft entered the denser layers of the atmosphere.

In March, 1960, "Experimental Satellite-Spaceships III and IV"

were propelled into orbit for two weeks. The successful completion of their missions paved the way for Gagarin's orbital flight. In both cases, the dogs and other animals in the space cabins were returned to earth unharmed.

Thus, a reentry procedure which was both safe and reliable had been developed making it possible to propel astronaut Gagarin into orbit in the Vostok I on April 12, 1961.

Reentry Procedure

The Soviet spacecraft reentry procedure, developed in 1960, can be divided into three stages.

1. When, in the course of its final orbit, the satellite emerges from the umbra of the Earth, its automatic orientation system is switched on. This directs the spacecraft (while orienting it in the desired direction with respect to the sun and the horizon) so that the retrorocket thrust will be directed in a direction opposite to the orbital motion of the satellite. The retrorockets are then fired at the desired moment whereupon the velocity of the capsule is reduced by several hundred m/s. Then the craft is positioned in the proper reentry angle so that it will be able to enter the earth's atmosphere. This entire maneuver is performed automatically and was implemented during the return-to-earth operation of all six Vostoks.

Reentry could also have been accomplished through manual control. If he so desired, the astronaut could override the programmed installations and could steer the craft with the aid of an optical system. He could also control the firing of the retrorocket. The pilot decided when to activate the braking system on the basis of the information he obtained from a small revolving globe which indicated his position in relation to the Earth and, in case a premature landing was necessitated, it also specified the landing site.

2. After the retrorocket has been fired, the instrument section is separated from the space cabin. Since it is not equipped with a thermal shield, it later burns up in the denser layers of the atmosphere.

The space cabin is not provided with a special stabilizing system. No such system is needed because the aerodynamic forces which act upon the space cabin during reentry maintain it in the proper attitude. Ten minutes after the firing of the retrorocket, the cabin hits the denser layers of the atmosphere where its speed is further reduced by aerodynamic drag. This reduction steadily reaches 6 g and then it suddenly climbs to 8 g. Atmospheric temperature is at least 1,000°C; therefore, cabin temperature was maintained at about 20°C by the air conditioning system. The spacecraft is protected from the high temperatures resulting from aerodynamic drag by thermal shields. Heat can also be removed by means of dissipation. Subsequently, the rate of deceleration is reduced until the vehicle is traveling at less than the speed of sound. Thus, the critical phase of the reentry process is completed.

The distance traveled since the retrorockets were fired is 7000 kilometers. This was accomplished in 15 minutes as the velocity of the spacecraft was reduced from 8000 m/s to 200 m/s.

3. At this point, the astronaut is faced with two alternatives. He can remain in the capsule which will be brought safely to earth by two parachutes. One of these is the drogue parachute which opens at an altitude of 5000 meters. It reduces the speed at which the capsule falls to the ground and stabilizes it as well. It also triggers the opening of the main parachute and slows down the capsule to approximately 10 m/s. The landing is a relatively hard one, nevertheless, it is tolerable.

On the other hand, the astronaut may elect to abandon the capsule in his ejection seat when he is at an altitude of approximately 7000 meters and parachute to the ground. With the exception of Gagarin, all the astronauts used this latter method.

A Reliable System

A satisfactory reentry system was developed in 1961. No changes have been made in the first two stages; however, in the second and third generation of spaceships (Vostok and Soyuz), the ejection seat

was omitted and the astronaut did not abandon the craft. To reduce the impact at landing, small retrorockets were used which complement the main parachute and reduce the velocity of fall from 10 m/s to only a few cm/s at the moment of contact.

Seventy satellites have been successfully recovered by the Soviets since 1961. Eight of these were carrying either human or animal passengers. Thus, the reentry procedure was well tested and proved to be reliable.

Despite this, astronaut Komorov died during the reentry of his vehicle, the Soyuz I, into the atmosphere. Nevertheless, the accident could not be attributed to some malfunction which occurred during the critical reentry phase. Instead, it was caused by a faulty parachute which would not open.

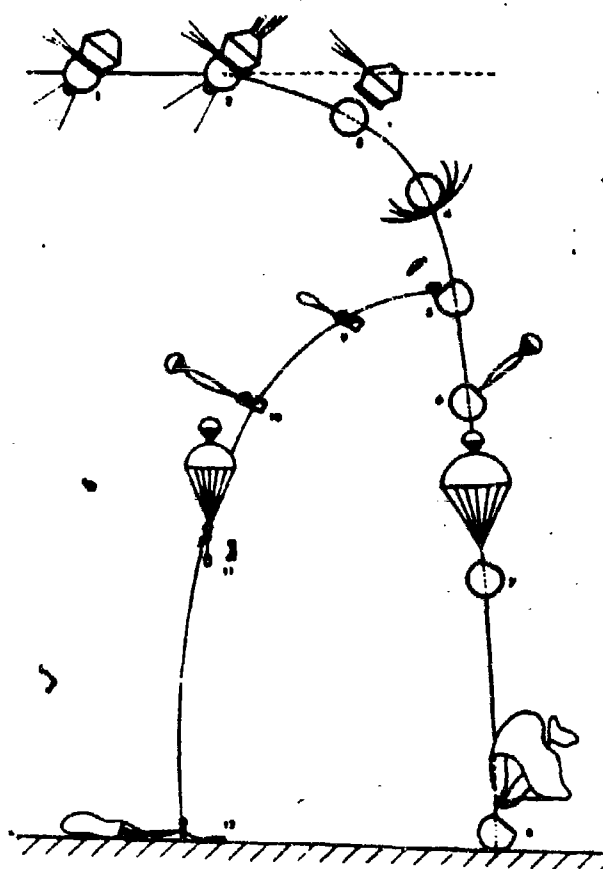


Fig. 1. Vostok spaceship re-entry diagram.

1 - Attitude control; 2 - retro-rocket fires; 3 - instrument section jettisons; 4 - further braking in space; 5 - astronaut ejects from capsule; 6 - drogue parachute of capsule opens; 7 - main parachute opens; 8 - landing at 10 m/s; 9 - drogue parachute of seat opens; 10 - main parachute deploys; 11 - main parachute opens and astronaut separates from his seat carrying an instrument package; 12 - astronaut lands.



**GRAPHIC NOT
REPRODUCIBLE**

Fig. 2. Preparing for launching of the Vostok spaceship, astronaut enters capsule in an ejection seat.



**GRAPHIC NOT
REPRODUCIBLE**

Fig. 3. Interior of space cabin. The small globe, which is utilized primarily when the astronaut employs the manual controls, is visible on the instrument panel.